Coastal Engineering Technical Note

COMPUTER PROGRAMS FOR HARBOR RESONANCE

PURPOSE: To provide a description of two computer programs, HARBS and HARBD, for calculating harbor resonance and wave scattering.

BACKGROUND: Harbor resonance is the phenomenon of amplification of a free wave in a harbor by a forced wave of equal period. The forced wave may be an incident wave or arise from a boundary condition. The resonance problem is severe in many harbors. It should be avoided or minimized whenever possible in harbor planning and operation. Numerous investigators (Chen and Mei 1974, Houston 1980) over the years have studied the harbor resonance problem, but most of the studies have been restricted to cases without bottom friction and boundary wall asbsorption. Consequently, the amplitudes of resonant peaks for a harbor predicted by traditional models are always high, sometimes unreasonably high. A typical example is shown in Figure 1.

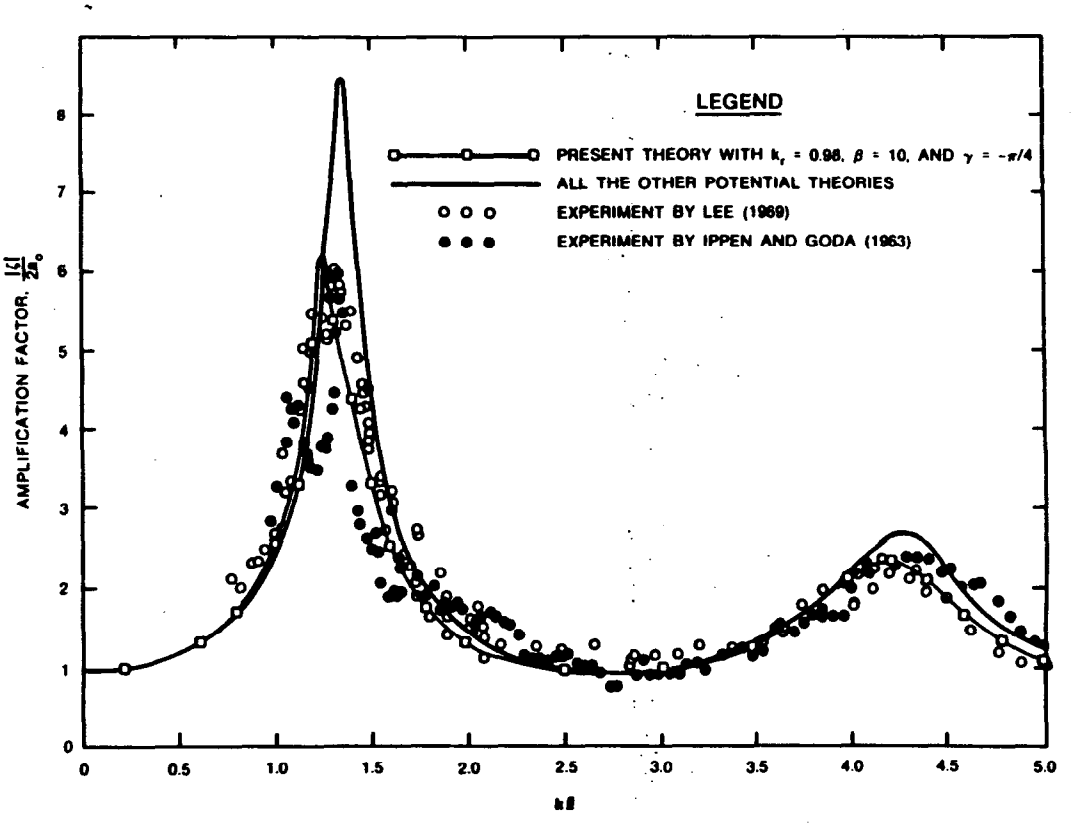

Figure 1. Amplification factor vs $k\ell$ at the back wall of the rectangular harbor in Figure 2 ($k\ell$ is the wave number)

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The inclusion of bottom friction and boundary absorption in the harbor resonance analysis, which has recently been accomplished in two CERC models (Chen 1984), signif icantly enhances the accuracy of predicted results for engineering application.

The computer programs are based on a mathematical model that assumes linear wave theory. However, it includes bottom friction and boundary absorption. Bottom friction is assumed to be proportional to the flow velocity with a phase difference. The boundary absorption involves a formulation identical to the impedance condition used in acoustics, and it is expressed in terms of wave number and the reflection coefficient of the boundary. A hybrid finite element method is employed to solve the boundary value problem. In this method, the entire water domain is divided into the near and far fields by an artifical boundary. The artifical boundary is chosen for convenience in computation. A conventional finite element approximation is used for the near field, while an analytical solution is used for the far field. A variational principle with a proper functional is established to ensure that the matching conditions are satisfied along the artifical boundary.

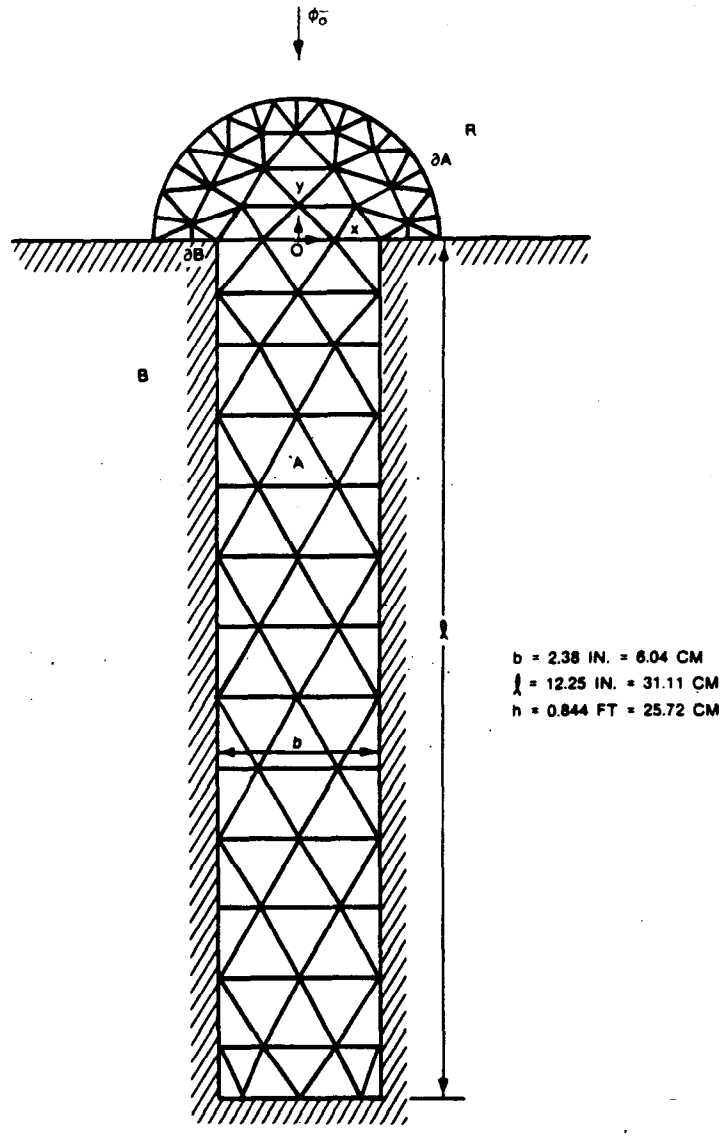

Figure 2. A fully-open rectangular harbor and its finite element network

PROGRAM DESCRIPTION: Two computer programs, HARBS and HARBD, are available at CERC for calculating harbor resonances and wave scattering due to bathymetry and marine structures. Both programs can be applied to a coastal or offshore harbor of arbitrary shape and variable depth. The programs can be run in either a monochromatic or spectral mode.

The HARBS program is applicable to shallow-water waves. It allows fixed platforms, either floating or bottom-mounted, in the water domain. Typical platforms which can be included are breakwaters, moored ships, pontoons, storage tanks, moored barges, etc. The program HARBS is intended for engineering applications and is less costly to execute than the HARBD program.

The HARBD program is applicable to shallow, intermediate, and deepwater waves. It cannot allow platforms in the water domain. Both programs are very efficient. For example, for the rectangular harbor of eighty-six nodes shown in Figure 2, calculation for each wave period takes only a few seconds on the CDC Cyber 170 Model 760 computer.

INPUT: The input data to the programs are:

1. Geometrical data: coastal configuration, bathymetry, platform configuration, and vertical clearance between the bottom of the platform and sea floor (if applicable).

2. Physical data: incident wave, bottom friction coefficients, and reflection coefficient of the wall boundary.

3. Finite element data: elements and nodes.

OUTPUT: The output of the programs consists of the amplification factor for wave amplitude and/or pressure and the phase difference relative to the incident wave. Wave forces are provided by the programs when requested. Flow particle velocity will be added as a program output in the near future.

PROGRAM AVAILABILITY: The programs are written in FORTRAN, but limited documentation is available at this time. At present, the models are set up for use by CERC personnel. More detailed documentation in a CERC Technical Report is scheduled for 1986 for the "Waves at Entrances" work unit. Sample

input and output and program limitations will be included. For more information, contact Dr. H. S. Chen at (601) 634-2025 or Dr. Edward F. Thompson at (601) 634-2027 Coastal Oceanography Branch, CERC.

REFERENCES:

Chen, H. S. and Mei, C. C. 1984 (Aug). "Oscillations and Wave Forces in an offshore Harbor," Report No. 190, Ralph M. Parsons Laboratory, Massachusetts Institute of Technology, Cambridge, Mass.

Chen, H. S. 1984 (Dec). "Hybrid Element Modeling of Harbor Resonance," Proceedings of Fourth International Conference on Applied Numerical Modeling, National Cheng Kung University, Tainan, Taiwan, pp 312-316.

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